

Understanding public views on a dam construction boom: the role of values

Christopher Schulz ^{a*}, Julia Martin-Ortega ^b, Klaus Glenk ^c

^a Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, United Kingdom; cs998@cam.ac.uk; <https://orcid.org/0000-0002-0206-2390>

^b Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, United Kingdom; j.martinortega@leeds.ac.uk; <https://orcid.org/0000-0003-0002-6772>

^c Land Economy, Environment and Society Research Group, Scotland's Rural College (SRUC), Peter Wilson Building, Nicholas Kemmer Road, Edinburgh EH9 3FH, United Kingdom; klaus.glenk@sruc.ac.uk; <https://orcid.org/0000-0002-2472-0235>

* corresponding author

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Abstract

Large numbers of dams for hydroelectric power production are currently planned or under construction in many areas around the world. While positive and negative social and environmental impacts of dams are increasingly well understood, little is known about attitudes of the general public towards dams, even though benefits to wider society are often cited to legitimise their construction. In Brazil's Upper Paraguay River Basin, more than 100 mostly small-scale hydropower dams are planned or under construction in what can be considered a regional dam construction boom. Here we analyse public preferences for strategies to manage dam impacts in the area by investigating the value base that underpins such preferences, drawing on the recently proposed Value Landscapes Approach as our theoretical framework and data from a large representative household survey (N=1067). We find that contrasting attitudes towards dams, expressed in preferences for economically or ecologically oriented water policies are informed by opposing underlying value landscapes, that is, groups of closely related fundamental, governance-related, and assigned (water) values. While such tensions between opposing values can never be fully eliminated, our research nevertheless gives insights to policy-makers seeking to minimise value conflict and to improve the political legitimacy of public decision-making on dam construction. Moreover, we find that a majority of members of the general public would prefer concentrating dam construction on some rivers while keeping others free-flowing, with direct implications for ecosystems and inland fisheries. This finding may guide policy-makers wishing to develop publicly supported water resources management strategies.

Keywords

water policy; water governance; hydropower; value landscapes; Mato Grosso; Brazil

1 Introduction

Thousands of dams are currently being planned and built in various regions across Asia, Africa, Latin America, and the Balkans (Zarfl et al. 2015). While decision-makers may often prefer to emphasise their economic benefits or technocratic nature, the development of large infrastructure also always has a strong political dimension (Meitzner Yoder 2018; Thurston 2018), i.e. views on its desirability may differ widely among different members of society and relevant stakeholder groups. Besides their uses for hydroelectric power production and storage of water for irrigation and domestic water supply, dams in particular have a diverse range of social and environmental impacts (WCD 2000). These may often disproportionately affect poor and marginalised populations, and create political dynamics around their construction, such as campaigns and activism against dams (Han 2013; Rothman 2001; Toshiko 1999). It is thus important to measure and understand views of the general public towards these infrastructure projects to provide insights on their political legitimacy (Schulz et al. 2018) and understand public support for water policies (Kochalski et al. 2019; Srdjevic et al. 2018).

This global dam-building boom has also reached Brazil's Upper Paraguay River Basin, located partly in the state of Mato Grosso, where more than 100 mostly small-scale hydroelectric power stations (locally known as *PCHs* or *Pequena Central Hidrelétrica*, with a capacity of less than 30 MW) are planned or under construction (Calheiros et al. 2012)¹. While researchers have begun to investigate the ecological, hydrological, and social impacts of these dams (Fantin-Cruz et al. 2015; Jaber da Silva and Sato 2012; Souza Filho 2013), knowledge gaps exist regarding public attitudes towards the current surge in dam construction. The present study is the first to investigate public attitudes towards this regional dam construction boom, which

¹ 'Small-scale' here refers to MW production (as consistent with usage of the term in Brazilian Portuguese), and is not directly related to the height of dams or reservoir size, i.e. the criteria that define 'large dams' more generally, following the International Commission on Large Dams (ICOLD) and the World Commission on Dams (WCD 2000).

may provide insights not only for the regional context, but broader lessons about societal views on dam construction and impact management. Such research complements methodological advances that have been made in the field of decision-support systems and software, which may help to optimise dam planning and selection of sites via a set of technical criteria and modelling of trade-offs (e.g. Park and Um 2018; Roozbahani et al. 2017), but do not (yet) incorporate public views.

The Upper Paraguay River Basin has a low population density, with most settlers concentrated in Mato Grosso's capital city of Cuiabá. Other significant economic activities are agriculture (particularly soybean and cotton) and cattle ranching, as well as tourism and fishing. The region also hosts the world's largest freshwater wetland, the Pantanal (Vinten 2012). Most dams are planned to be built upstream of the Pantanal (Calheiros et al. 2012). Changes in water flows as well as the physical barriers posed by these dams are expected to affect biodiversity and ecology of the wetland, especially the reproduction of migratory fish species (Agostinho et al. 2008). This, in turn, is likely to affect the livelihoods of small-scale subsistence fishers who live in small communities along most major rivers in the Upper Paraguay River Basin (de Oliveira and Nogueira 2000). It may also impact on the fishing tourism and ecotourism sectors, given that ecosystems in the Pantanal are highly dependent on healthy fish populations (Alho and Vieira 1997; Angelini et al. 2013; Shrestha et al. 2002).

We conducted a large household survey (N=1067) with a representative sample of members of the general public living in Mato Grosso's Upper Paraguay River Basin to understand public preferences for dealing with dam impacts on the livelihoods of subsistence fishers. Several strategies have been proposed locally, which overlap with some of the recommendations for the management of dam construction impacts made by scientists globally (Tagliaferro et al. 2013; Tundisi et al. 2014), giving relevance to our case study beyond the particular local context. One strategy currently gaining traction in the river basin is the introduction of fish

farming (Alho 2008; Toledo and Penha 2011), which reduces the dependency on increasingly scarce river fish stocks, and may also lead to growth in the formal economy (Cavalett et al. 2007; Déo Dias et al. 2012; Saint-Paul 2017). Fish farming is already carried out in many places elsewhere around the globe where dams have interrupted routes of migratory fish (see e.g. Jellyman et al. 2016). Yet this requires significant financial investment and capacity building. Another strategy would involve keeping some rivers free of dams and concentrate hydroelectric power production on some tributaries to the Paraguay River only, which would also be in line with scientific assessments of the ecological importance of free-flowing rivers more broadly (see e.g. Miho 2018; Tagliaferro et al. 2013). This way, subsistence fishers would be able to maintain their livelihoods at least in some locations, with additional benefits for biodiversity and ecosystems. While it is clear that dams have multiple and varied impacts, we chose to focus on small-scale fishers' livelihoods as an example with high cultural and symbolic importance for the region (de Fátima Mateus and Ferreira Penha 2018), with the two different strategies encapsulating quite distinct implicit values. Previous qualitative research in the river basin has shown that some people may favour cultural-ecological values and water policies (which are implicitly favoured in the first strategy), yet others prefer approaches with a primary focus on economic values of water resources and economic development (which are implicit in the second strategy) (Schulz et al. 2017b). However, no previous research has tested whether such values may relate with preferences regarding dam planning and construction.

In line with a growing body of evidence, we propose that people's preferences for such different water policies can be interpreted as expressions of their values (Bjornlund et al. 2013; Gooch and Rigano 2010; Kochalski et al. 2019; Kuruppu 2009; Retallack and Schott 2014; Russo Bauer and Smith 2007), although there is also emerging evidence that different water policies can shape people's values (Albizua et al. 2019). As the theoretical basis for our study, we use the recently proposed 'Value Landscapes Approach' (Schulz et al. 2017a, 2017b; Schulz et al.

2018). This interdisciplinary conceptual framework suggests that people (including stakeholders and members of the general public) hold different kinds of values, related in groups of values (or ‘value landscapes’), which may all be related to their preferences in (water) governance and policy (more details in section 2). The present study is the first to apply this conceptual framework to the issue of dam planning and construction, building on the conceptual work and first empirical test outlined in Schulz et al. (2018).

Despite a growing awareness that a better understanding of people’s values is necessary to make sense of conflicts in water governance and water policy-making (Meisch 2014; Schmidt and Peppard 2014; Schulz 2019), there is still scope to improve the empirical evidence base to substantiate such claims. Our objective here is thus to contribute to the empirical literature on linkages between values, governance and policy preferences by evaluating whether we can identify statistically measurable links between people’s value landscapes and their preferences regarding strategies for dealing with hydropower dam impacts on small-scale fishers. This research objective also addresses the need for better understanding of public attitudes towards dam construction and dam impact management strategies, which has implications for their political legitimacy. Towards this end, we employ structural equation modelling (SEM) techniques, a quantitative empirical approach suited for testing hypotheses on interrelationships between multiple latent variables and preferences (Garson 2015).

The findings of our study serve as further empirical evidence on the role of people’s values as determinants of water policy preferences, and represent an attempt to translate interdisciplinary conceptual thinking into real-world applications. They also serve as rare evidence of public preferences for a thorny water policy issue which pits environmental conservation and the maintenance of traditional cultural practices against economic modernisation and development. Our study thus has relevance for other contexts, where policy-makers need to decide on how best to deal with the impacts of a rapidly expanding hydropower sector (Calheiros et al. 2012),

manage inland fisheries (Shirley and Gore 2019), or, more broadly, negotiate environment vs. development conflicts (Schulz et al. 2018). Our research also creates the opportunity to incorporate citizens' views in water resources management, even though ordinary citizens are often perceived as disconnected or uninterested in water policy (Srdjevic et al. 2018).

2 The Value Landscapes Approach and preferences for strategies to alleviate the impact of dams

The 'Value Landscapes Approach' is an interdisciplinary conceptual framework to guide the investigation of diverse values that are implicit in water governance², and environmental governance more broadly (Schulz et al. 2017a, b). An application and discussion of the framework can be found in the quantitative study by Schulz et al. (2018). Its main objective is to understand how water and environmental governance may be shaped by people's values and vice versa, while clearly distinguishing between various types of values expressed by humans as established by several different disciplines.

Specifically, it suggests investigating three types of values: (i) assigned (water) values, (ii) governance-related values, and (iii) fundamental values. The first type covers values assigned to external objects and natural resources, for example the multiple uses and benefits from water, such as fish or drinking water, which may be place-specific (Lockwood 1999; Seymour et al. 2010). In this sense, it is conceptually close to the notion of ecosystem services, although the term 'assigned values' precedes that of ecosystem services. The term 'assigned values' is also more open-ended and flexible than ecosystem services, considering that the latter term implicitly favours utilitarian values and ways of relating to the natural environment (Muradian 2017). The second type (governance-related values) covers idealised characteristics of

²Water governance defined here as the combination of water policy (the content of decision-making), polity (the institutional framework), and politics (the power play between different actors) (Schulz et al. 2017a), inspired by previous work on the broader concept of governance (Treib et al. 2007). Water-related policies, such as the potential dam impact management strategies described above, are thus considered as one of the elements of governance.

governance, such as sustainability, social justice, or economic efficiency (Glenk and Fischer 2010). These values are often the topic of studies of good water governance (Schulz 2019) and governance principles more generally (Pahl-Wostl et al. 2012). Governance-related values also share similarities with the concept of public values (Beck Jørgensen and Sørensen 2013; Ćwiklicki 2016), yet with the main difference being that governance-related values may apply to governance beyond the public sector. The third type has its roots in social psychology and refers to people's abstract goals, which they seek to realise across decision-making situations (Fulton et al. 1996; Schwartz 2012). Examples of fundamental values are receiving other people's admiration, leading a self-directed life, or searching for personal security. In the widely used Schwartz Value Theory, these values are often categorised within the broader dimensions of self-enhancement and self-transcendence, as well as openness to change and conservation (Schwartz 2012).

The Value Landscapes Approach theorises that these groups of values are related to each other in a configuration (a value landscape, in the metaphor) that determines people's preferences in (water) governance (Schulz et al. 2018). This is based on the premises that: values exist at different levels of abstraction (from the more abstract fundamental values to the more concrete assigned values), with more abstract values influencing the more concrete values; there is a strong interrelatedness between water governance and values; and that value pluralism is an empirical reality that can be studied. Investigating people's values in the form of value landscapes allows a deeper and more complex understanding of their preferences. The Value Landscapes Approach, which due to its focus on plural values can be placed in the theoretical tradition of the field of ecological economics (Munda 1997; Saes and Ribeiro 2018), provides a structured answer to many calls to take values into account in water governance (see e.g. Meisch 2014; Schmidt and Peppard 2014), by clarifying the various types of values that exist and how they may be related to concrete preferences among relevant stakeholders as well as

members of the general public. This helps evaluating the political legitimacy of certain aspects of water governance through a comparison of values expressed by different stakeholder groups or members of the general public with values that are implicit in concrete governance issues.

The above is useful in relation to decision-making about dams, because they represent an epitome of conflicts between environmental conservation and the maintenance of traditional cultural practices against economic modernisation and development. For the case of the Upper Paraguay River Basin, previous qualitative research has shown how such conflicting views may be grounded in preferences for cultural-ecological water policies, whereas others may prefer approaches with a primary focus on economic aspects (Schulz et al. 2017b). These contrasting preferences may also have implications for understanding preferred strategies to deal with the impacts of dams.

The first strategy considered here would involve helping subsistence fishers to move from fishing to fish farming, by providing fish tanks and offering training on how to operate these. This strategy would allow fishers to become independent of river fish, and is often advocated by business-oriented stakeholders in the region (Schulz et al. 2017b). Not least, it has been argued that fish farming may contribute to economic growth (Pincinato and Asche 2016), as fishers may increase their participation in the regional fish trade (Cavalett et al. 2007; Déo Dias et al. 2012; Saint-Paul 2017), and this way, it could mitigate some negative economic impacts of the current hydropower boom in Mato Grosso's Upper Paraguay River Basin on the affected population of fishing communities. A second strategy could involve helping subsistence fishers to maintain their traditional way of life by keeping some rivers free of dams, and this way, avoiding any interference with fish stocks at least in some areas. Small-scale fishing is an important element of traditional culture in the Pantanal area, where many traditional festivities are celebrated on boats or on the shores of the rivers (Loureiro 2006; Schulz and Ioris 2017). This strategy would mean that dams were concentrated in some rivers only to mitigate negative

impacts elsewhere. This would also benefit local biodiversity and ecosystems. We hypothesise that people's preferences for one of the two strategies are related to their value landscapes (see section 4).

3 Methodological approach

3.1 Structural equation modelling

Structural equation modelling (SEM) is an established method to empirically test complex theoretical relationships. SEM combines path analysis (for the analysis of potentially causal relationships between variables) with confirmatory factor analysis (for the measurement of latent variables via quantitative survey research) (Garson 2015). It is frequently applied to test relationships between people's values, norms, and other latent constructs with attitudes towards environmental issues, such as e.g. water conservation (Yazdanpanah et al. 2015). This makes SEM a suitable tool for testing hypotheses on linkages between people's value landscapes and their preferences for water policy.

3.2 The sample

This study draws on data from a household survey with members of the general public in the Upper Paraguay River Basin in Mato Grosso (N = 1067), conducted between April and June 2016 by a team of trained local enumerators. A large number of dams are projected to be built in this hydrographic basin (Calheiros et al. 2012), whose rivers sustain the Pantanal wetland, and where many traditional subsistence fishing communities still exist alongside the major rivers (Chiaravalloti 2017). The sampling procedure was designed to produce a representative sample of the general population according to multiple socio-demographic variables, as described in more detail in Schulz et al. (2018).

3.3 Questionnaire design

The questionnaire included sections on socio-demographics, fundamental values, governance-related values, assigned values, and preferences about regional water governance issues,

including regarding the mitigation of dam impacts. Fundamental values were measured with the 21-item Schwartz Portrait Value Questionnaire (PVQ) (Schwartz 2001), which has been developed to allow application to respondents of any cultural and educational background, and has been tested extensively in empirical research, including in Brazil (Tamayo and Porto 2009). This yielded data on the ten fundamental values proposed by Schwartz (2012).

Governance-related values were measured with a customised measurement instrument, based on previous qualitative research in the area (Schulz et al. 2017b). This instrument was developed via exploratory (EFA) and confirmatory factor analysis (CFA) (see Schulz 2019 for a detailed description). Two of the three governance-related values identified via EFA and CFA were used in the present study, namely *democratic governance-related values* (composed of survey items capturing democratic legitimacy and social justice) and *economic governance-related values* (composed of survey items capturing economic efficiency and rule of law/order).

Likewise, a customised measurement instrument was used to measure assigned values, based on EFA and CFA of survey items, which produced three separate assigned or water values, namely *ecological water values* (composed of survey items capturing the role of rivers and waterbodies for the survival of wildlife and of the Pantanal wetland's natural environment), *cultural water values* (composed of survey items capturing the importance of rivers and waterbodies for the maintenance of traditional lifestyles, including subsistence fishing, and cultural traditions, such as traditional festivities), and *economic water values* (composed of survey items capturing the importance of rivers and waterbodies for agriculture and cattle ranching, as well as for hydroelectric power production).

Preferences regarding the mitigation of dam impacts were captured via a vignette, which described the policy dilemma between hydroelectric power production and the impacts on subsistence fishers (see Box 1).

Box 1: Vignette for measuring water policy preferences used in the survey questionnaire (translated from the original Portuguese)

I would also like to know your opinion about the construction of hydroelectric power stations here in the region. There are already 44 hydropower stations, and the construction of another 110 is planned in the Brazilian part of the Paraguay River Basin which includes the nearby rivers such as the Cuiabá River, São Lourenço, Manso, Jauru, and Sepotuba.

70% of Brazil's electric energy comes from hydropower. It pollutes less than the majority of the other energy sources, such as for example the thermal power stations which use coal. But it also changes the natural flow of water in the rivers and interrupts fish migratory routes. This results in a decrease in fish numbers in rivers and today's fishers already have difficulties maintaining themselves in the affected rivers.

Now, several different strategies have been proposed to diminish this problem. I would like to know: which of the following options would you prefer?

- a) The government helps the fishers to build fish tanks to raise fish so that they do not depend on fishing in the river. In the future, they would maintain themselves by raising fish in tanks and selling them.
- b) The government limits the number of hydroelectric power stations and ensures that some rivers remain without them. In those rivers, fishers could continue fishing like in the past.

4 Results

Overall, 28.3% favoured the first option listed in Box 1, i.e. helping local fishers to adopt fish farming techniques and fish tanks, whereas 70.29% of respondents favoured the second option, i.e. keeping some rivers free of hydroelectric power-producing dams (the remainder refused to answer/didn't know).

4.1. Hypotheses on value landscapes and water policy preferences

Based on the Value Landscapes Approach and considering previous empirical research (Schulz et al. 2017b; Schulz et al. 2018), two hypotheses emanate that relate people's value landscapes

with their water policy preferences expressed in the forms of the two options listed in the vignette above. These were operationalised as one structural equation model each.

The first hypothesis relates an ‘economic value landscape’ with a preference for supporting a transition from subsistence fishing to fish farming in the Upper Paraguay River Basin to mitigate dependency on free-flowing rivers. This value landscape was previously identified and measured by Schulz et al. (2018). We expected positive relationships between self-enhancement fundamental values and economic governance-related values. Economic governance-related values emphasize efficiency and the rule of law, which relate well to the fundamental value of achievement, which is part of the self-enhancement dimension (Schwartz 2012). We expected positive links between self-enhancement and economic assigned values, as similar links have been previously found in empirical research (e.g. Kilbourne et al. 2005). We expected positive links between economic governance-related values and economic assigned values, given that these were often jointly mentioned by stakeholders from the water sector in previous qualitative research in the river basin (Schulz et al. 2017b). Overall, both economic governance-related values and economic assigned values of water (such as use for hydropower or irrigation) relate well with a preference for prioritising economic development in natural resource governance. We thus expected this value landscape to relate positively with a dam impact management strategy that, in theory, could lead to economic growth. This hypothesis is formalized as follows:

H1: Those who hold an economic value landscape (self-enhancement fundamental values; economic governance-related values; economic assigned values) will prefer to mitigate dam impacts on subsistence fishers by helping them to adopt fish farming as a new livelihood strategy.

A second hypothesis relates a ‘cultural-ecological value landscape’ with a preference for keeping some rivers free of dams. This value landscape was also previously identified and measured by Schulz et al. (2018). We expected positive links between self-transcendence fundamental values and democratic governance-related values, since democratic governance-related values imply a responsibility to care for other people and their views. This corresponds well to the dimension of self-transcendence, which is equally defined by caring about other people (and non-humans) (Schwartz 2012). We expected positive links between self-transcendence and ecological assigned values, given that these have been identified by many previous studies (e.g. Schultz et al. 2005). We expected positive links between democratic governance-related values and ecological and cultural assigned values, given that these were also often jointly mentioned in previous qualitative research in the study region (Schulz et al. 2017b). One reason for this might be that the former include caring about the poor and marginalised; conserving water-related cultural traditions in Mato Grosso relies precisely on poor and marginalised riparian communities. Nevertheless, we acknowledge that theoretically, this might be a less straightforward assumption. Finally, we expected this value landscape to relate positively with the strategy of keeping some rivers free of dams, as this would best ensure maintaining their ecological integrity, and thus, existing cultural traditions (which were developed in the context of free-flowing rivers, i.e. under a natural seasonal flooding regime). This hypothesis is formalized as follows:

H2: Those who hold a cultural-ecological value landscape (self-transcendence fundamental values; democratic governance-related values; ecological and cultural assigned values) will prefer to mitigate dam impacts on subsistence fishers by keeping some rivers free of dams.

4.2. Results of structural equation modelling

Most, but not all of our expectations regarding hypothesis 1 are confirmed by the SEM results (see Figure 1). Self-enhancement fundamental values do indeed relate strongly with economic

governance-related values, but not with economic water values (which may potentially be due to mediation effects, see Schulz et al. 2018). Economic governance-related values show a positive relationship with economic water values; and economic water values relate positively with a preference for replacing subsistence fishing with fish farming. All model parameters except the p-value of χ^2 indicate good model fit, i.e. CFI and TLI exceed 0.95, RMSEA is lower than 0.06 and SRMR is lower than 0.08 (Garson 2015; Hu and Bentler 1999); and while the p-value of χ^2 is significant, Garson (2015) has pointed out that it may suggest rejection of most models above a sample size of 200.

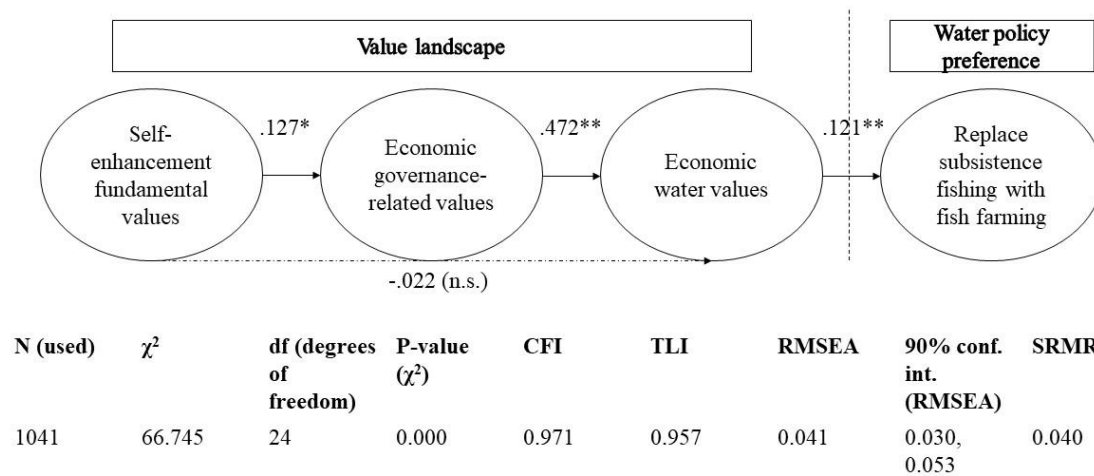


Figure 1: Economic value landscape and link with policy preference; * indicates significance at 0.1 level; ** indicates significance at 0.05 level; *** indicates significance at 0.01 level

Most of our expectations regarding hypothesis 2 also match SEM results; self-transcendence fundamental values do indeed relate positively (with a high degree of statistical significance) with both democratic governance-related values and ecological water values; democratic governance-related values do relate positively with ecological water values; and ecological water values have a positive relationship with a preference for keeping some rivers free of dams (even if the association is not as strong as we expected). Nevertheless, our hypothesis regarding the importance of cultural water values was not confirmed. While cultural water values may have strong internal links within their value landscape (see also Schulz et al. 2018), no

consistent links with the water policy preference could be found here. Thus, we excluded this variable from our analysis, and Figure 2 only shows ‘ecological water values’ as a relevant type of assigned values.

Overall model parameters are all within the range of what is generally considered good model fit in SEM research, i.e. the p-value of χ^2 is not statistically significant, CFI and TLI are greater than 0.95, RMSEA is below 0.06 and SRMR is below 0.08 (Garson 2015; Hu and Bentler 1999).

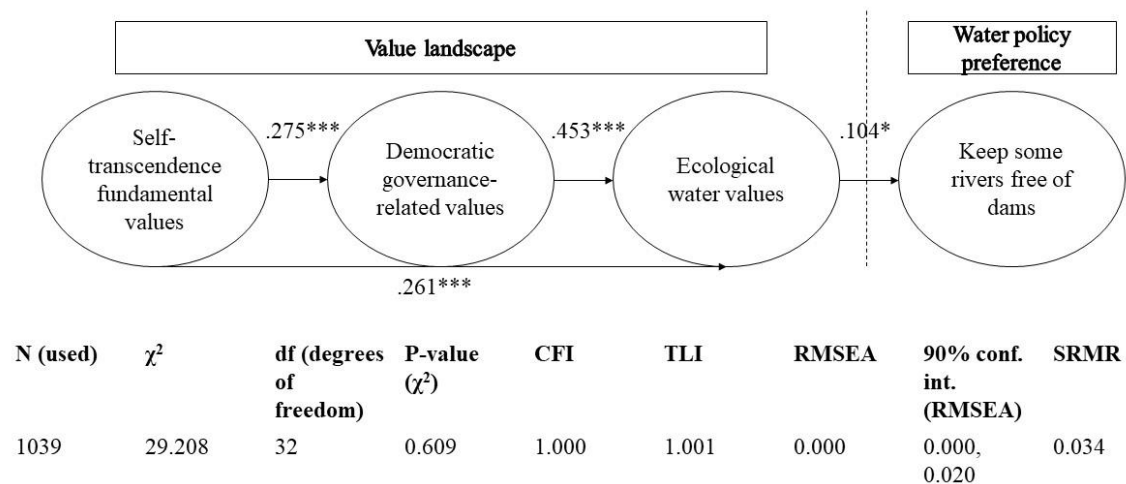


Figure 2: Ecological value landscape and link with policy preference; * indicates significance at 0.1 level; ** indicates significance at 0.05 level; *** indicates significance at 0.01 level

5 Implications and conclusions

In this paper, we have sought to unveil public preferences for dealing with the adverse impacts of hydroelectric power dam construction on subsistence fishers in the Upper Paraguay River Basin, Mato Grosso, Brazil, as a means of furthering knowledge on how these are underpinned by people’s values (fundamental, assigned and governance-related). This answers many calls ‘to take values into account’ to understand and address conflicts in water governance (see e.g. Meisch 2014; Schmidt and Peppard 2014) and improves our understanding of the political legitimacy of water policies and governance.

Most significantly, we find that people's water policy preferences are rooted in their value landscapes, as evidenced by the statistical analysis presented above. A preference for subsidising fish farming is linked to an economic value landscape, whereas a preference for keeping some rivers free-flowing is linked to an ecological value landscape; both value landscapes consist of contrasting fundamental, governance-related, and assigned values. These results resemble those in the only other previous quantitative study of value landscapes, and may confirm the universality of environment vs. development conflicts as being underpinned by certain configurations of people's values (Schulz et al. 2018). These may surface in water policy preferences as in the present case study, but also in very different contexts, where survey respondents can be clearly grouped e.g. into those deriving pleasure from shopping (as an economic activity) as opposed to nature experiences and vice versa (Craig et al. 2018). Recognising that such opposing viewpoints are grounded in values suggests that policy-makers may wish to adopt specific methods suited for the resolution or mediation of value conflict (e.g. Karjalainen and Järviöski 2010; Rauschmayer and Wittmer 2006). Additionally, our findings echo previous research that suggests that the majority of the general public tends to favour ecological water values over other values (Kochalski et al. 2019).

We have found that a majority of survey respondents favoured keeping some rivers free of dams, a finding which could already guide environmental planners and regulators in the region. This would ensure that dam-building would take into account public views, an important element of the political legitimacy of public decision-making (Schulz et al. 2018). Choosing the public's preferred strategy might also strengthen public support for environmental management in the region (cf. Kochalski et al. 2019; Srdjevic et al. 2018). Not least, such a strategy would also take into account recommendations made by ecologists who have highlighted the critical importance of keeping some rivers free-flowing to maintain connectivity between different ecosystems (Anderson et al. 2006; Finer and Jenkins 2012) and

sustaining the health of riparian ecosystems (Nilsson and Berggren 2000). A further benefit of keeping some free-flowing rivers is their higher recreational value (Getzner 2015). In the case of the Upper Paraguay River Basin this is being harnessed via ecotourism activities (Maruyama et al. 2005), although some have cautioned against potentially unequitable social impacts of nature-based tourism (Arts et al. 2018).

Nevertheless, a substantial minority of respondents would prefer supporting subsistence fishers by helping them to adopt fish farming techniques. Some have argued that this would be a desirable strategy for growing the economy and reducing pressure on river fish stocks (Cavalett et al. 2007; Déo Dias et al. 2012; Saint-Paul 2017), despite some potentially negative implications for water quality (Toledo and Penha 2011). This strategy would also maximise hydroelectric power production from rivers, which could be used for industrial applications and economic development.

In the present case neither strategy for managing the impacts of the region's dam construction boom can eliminate conflicts altogether. If policy-makers choose to concentrate dams on some tributaries, they are likely to face opposition from affected communities and contribute to inter-community conflict; if they choose to subsidise fish farming as a dam impact mitigation activity instead, it is likely that intra-community conflict will emerge around the distribution of public support and receipt of fish farming materials and capacity building. While the two management strategies discussed here were presented as alternative options for research purposes, in practice, any degree of combination between the two is evidently possible. In any case, it is clear that implementing a strategy based on the values of a majority of citizens would enhance its political legitimacy and may thus reduce overall magnitude of conflict and associated public opposition, e.g. in the form of activism. The present paper thus offers theoretically grounded policy guidance on a difficult water policy issue, and shows how interdisciplinary conceptual

thinking can be translated into real-world applications, with broader relevance beyond the case study which was used to illustrate these points here.

Conflict of interest

The authors declare that they have no conflict of interests.

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